Analysis of Alternatives

The Analysis of Alternatives (AoAs) is an important element of the Defense acquisition process. The AoA is important in determining whether or not a system should be procured. AoAs must not only make a case for having identified the most cost-effective alternative, they must also make a compelling statement about the military utility of acquiring it. In short, the AoA is a vehicle used by senior leadership to debate and assess a program's desirability and affordability.

An AoA is an analytical comparison of the operational effectiveness and cost of proposed materiel solutions to shortfalls in operational capability (these shortfalls are also known as mission needs). AoAs document the rationale for identifying a preferred solution or solutions to the shortfalls. Threat changes, deficiencies in fielded equipment, advances in technology, or the obsolescence of existing systems can trigger an AoA.

The most common AoA is conducted before an acquisition program is established. This type of AoA typically explores numerous conceptual solutions with the goal of identifying one or more promising options. An AoA, which occurs after a program is established, provides a more detailed definition and comparison of remaining options. An AoA is unlikely to be required at Milestone C unless significant changes to threats or technology have occurred or there was either an incomplete or no Milestone B analysis performed.

Links have been inserted throughout the text to enable you to quickly access definitions. It will help if you first click on the View portion of the toolbar, select Toolbars, and then select Web. To access a link or definition, move the cursor over the underlined expression, press and hold the Control key as you click the left mouse button. You will note that a green arrow appears on the far left of the Web toolbar. After you have accessed and read the definition of a term, you may click on the green arrow to return to the exact place in your text from where you accessed the hyperlink. This feature is being incorporated into other readings

Learning Objectives

1. Identify two uses of the Analysis of Alternatives (AoA).
2. Identify those systems for which an AoA is required.
3. Describe the role of the Overarching Integrated Product Team (OIPT) and the working-level Integrated Product Teams (WIPT).
4. Describe the role of the study performer, Study Advisory Group (SAG), and the functional proponent.
5. Describe the scope of the AoA work effort for every life cycle phase.
6. Contrast the difference between performance and effectiveness.
7. Define modeling and discuss modeling techniques that are applicable to operational effectiveness analysis.
8. Define Measures of Effectiveness (MOE) and describe the hierarchy of MOEs.

Requirements Determination

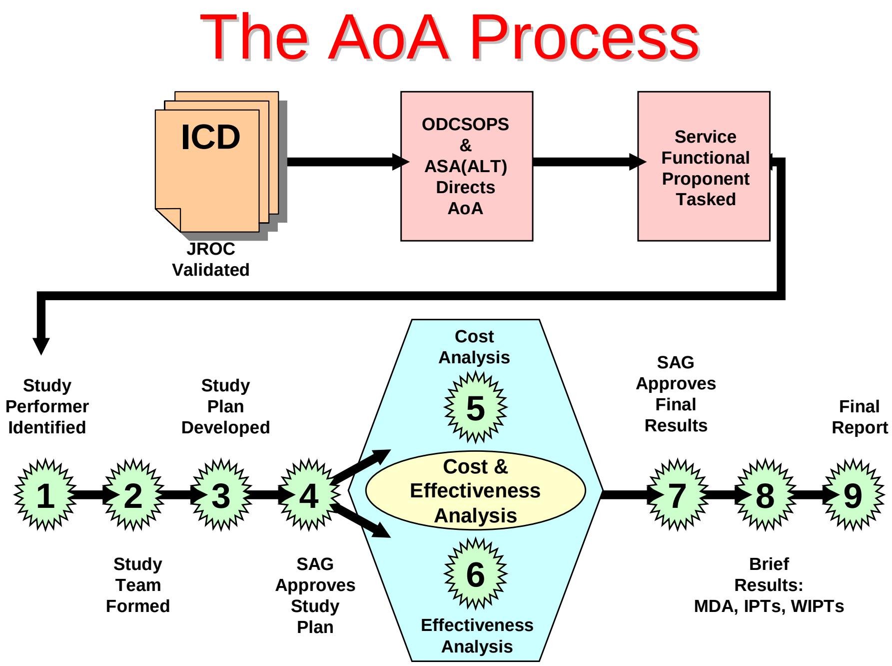
Headquarters, Department of the Army (HQDA) Office of the Deputy Chief of Staff for Operations and Plans (ODCSOPS), in coordination with the Assistant Secretary of the Army for Acquisition, Logistics and Technology (ASA (ALT)), will task the Service functional proponent, usually Training and Doctrine Command (TRADOC) to perform AoAs for Acquisition Category (ACAT) I and II programs. The functional proponent will designate a study performer to carry out the actual work involved in performing the AoA. In general, the proponent will issue a tasking document which contains issues, alternatives, broad guidance, and specific instructions, and appoint the Study Advisory Group (SAG).

When tasked as the functional proponent, TRADOC will usually task the TRADOC Analysis Center (TRAC) to conduct AoAs that support ACAT I and some ACAT II programs. The combat developer (CBTDEV) is responsible for conducting the remaining ACAT II, III, and IV program AoAs, if required by the Milestone Decision Authority (MDA).

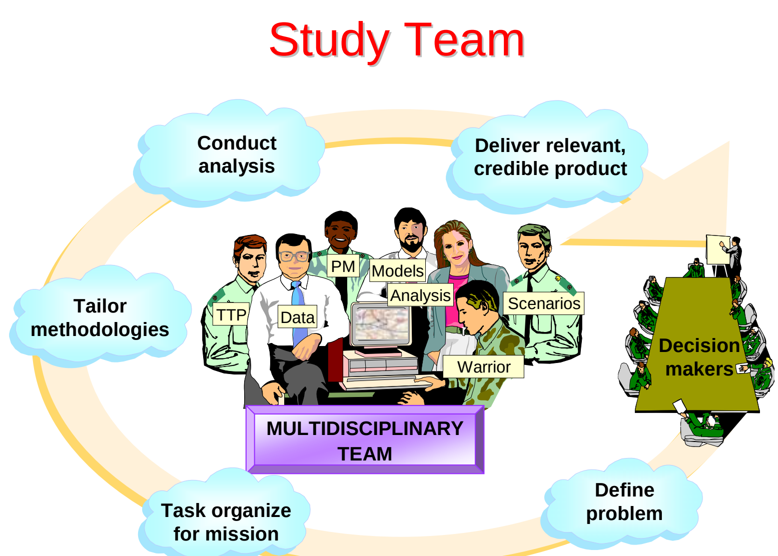
The analysis team usually includes members from both TRADOC and the Army Materiel Command (AMC) communities. AMC supports the study with representatives typically from the Materiel Developer (MATDEV); the Research, Development and Engineering Center (RDEC) Labs; and the Army Materiel Systems Analysis Activity (AMSAA). The MATDEVs and RDECs supply system specific cost and performance data, and results of engineering studies for input to the study.

The study performer is designated by the service functional proponent and has the overall responsibility for the content, completeness, and quality of the AoA. The study performer takes direction from the functional proponent and, guidance from the HQDA SAG or, for a Joint AoA, the Joint Oversight Board (JOB).

The AoA study performer is a full-time job benefiting from mature leadership skills and continuity of service. Ideally, the study performer is a major or lieutenant colonel (or civilian equivalent) from the lead command. Typically, a deputy from the same command supports the study performer, along with experienced analysts to lead the effectiveness and cost analysis processes. Guided by a high-level Overarching Integrated Product Team (OIPT) and working-level Integrated Product Teams (IPT), the performer prepares a study plan which contains issues, alternatives, scope, schedule, and analytical resources and submits the plan to the SAG for review. Upon completion of the analysis, the performer compiles the written AoA report.



Highly skilled members of the study team are recruited from several organizations. The composition of the study team depends on the specific AoA requirements. Members often include contractors who provide critical skills and resources. The team focuses on defining alternatives, then assessing and comparing their operational effectiveness and life cycle costs.



The study team is generally organized along functional lines into panels with a chair for each panel. Typical functional areas for the panels are threat and scenarios, technology and alternatives (responsible for defining the alternatives), operations concepts (of the alternatives), effectiveness analysis, and cost analysis. While the work of all the panels is vital to the AoA, the effectiveness analysis panel—chief integrator of the work of the other panels—occupies the pivotal position.

The panels meet separately to address their fundamental issues. They also meet in conjunction with other panels or the study team as a whole to exchange information. Frequent and open exchange of ideas and data is key to a successful AoA. The importance of this is greatest when the team members are geographically dispersed—a common occurrence.

Open communication is enhanced by documenting questions, answers, and decisions made in the various panels. This can be done through taking and distributing minutes of panel meetings. Frequent interaction via telephone and e-mail at all levels should also take place.

Another key to success is keeping the AoA study team intact throughout the AoA. A changing membership diminishes the corporate memory and creates delays as new personnel are integrated into the effort.

AoA Oversight and Review

AoAs are subject to substantial oversight and review because of their importance. The AoA supports program decisions at the OIPT and Defense Acquisition Board (DAB) level. IPTs perform much of the oversight; for ACAT ID and ACAT IAM programs, there are the OIPTs and one or more working-level IPTs (WIPTs). The OIPT reviews the AoA effort at the following points:

- Completion of AoA study plan
- Completion of AoA final results briefing
- When significant problems or changes arise

WIPTs are formed to support a particular process or functional area. WIPTs supporting the AoA process may be focused on test, operational requirements, logistics, etc. A WIPT formed to oversee the development of the AoA and other cost/effectiveness issues is generally called a Cost Performance IPT (CPIPT). The CPIPT is perhaps the most important from an AoA oversight and review perspective. WIPTs review the AoA at the following points:

- Completion of AoA study plan
- Completion of AoA
- As a result of any changes, updates or problems related to the AoA effort

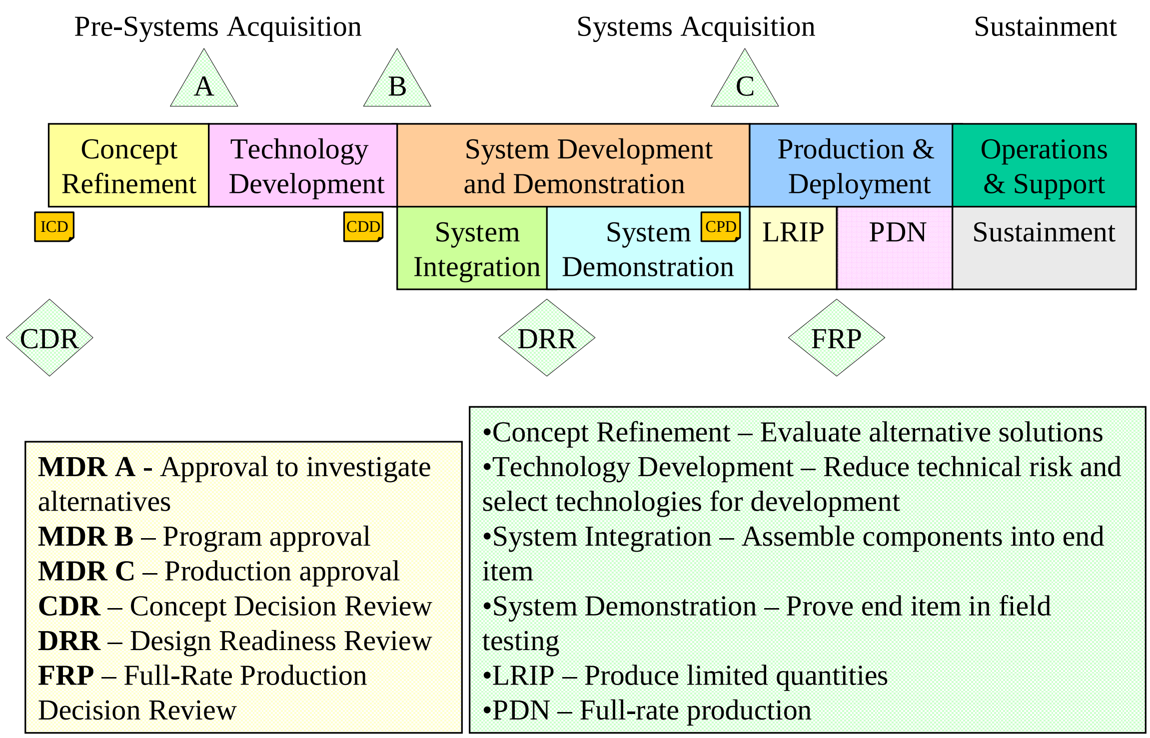
AoAs for ACAT I and II programs usually take 12-15 months to complete. Analysis requirements must be projected early to ensure analysis resources are available. Key resource drivers are study issues, methodology, and data requirements. Development of a plan to identify the data requirements, data sources, and the data supply schedule is a key element of the study plan. AMSAA assists the study team to identify and develop data requirements and sources. AMSAA also provides certified data for the AoA as required by TRADOC.

If an AoA is not required for an ACAT III or IV program, the CBTDEV maintains an audit trail of the materiel need determination process and requirements/operational analyses conducted to provide the analytic underpinning for the Capabilities Development Document (CDD).

Life Cycle Support

Prior to the Concept Decision Review, the services' capabilities integration and development system is supported by both strategic analyses, and by operational analyses. By examining global threats, current and projected US force capabilities, potential technology advancements, national military strategy, and concepts and doctrine, the capabilities integration and development system determines service needs for revised or new doctrine, organization, training, materiel, leadership, personnel and facilities (DOTMLPF). Most Initial Capabilities Documents (ICDs) result from this assessment. Analyses are conducted that provide rationale as to why non-materiel options are unfeasible or undesirable. These analyses examine known, approved programs to assist in determining whether concept studies are warranted for potential new start acquisition programs. No AoA is necessary prior to the Concept Decision.

THE LIFE CYCLE MODEL



During the Concept Refinement and Technology Development phases, the focus of analysis is on broad operational capabilities, potential technology concepts, and materiel solutions that could satisfy the ICD. The primary objectives of the AoA are to provide information to illuminate whether a new program is warranted and, if so, to identify Key Performance Parameters (KPPs). The full range of materiel alternatives (including those identified in the Acquisition Decision Memorandum (ADM)) must be considered. These alternatives may include the existing system, a modified existing system, programmed systems, other services' systems (either existing or programmed), non-developmental items (NDI), Allied developmental systems, and conceptual systems. The AoA determines the operational effectiveness and costs (including estimates of training and logistics impacts) for all alternatives; identifies KPPs for the preferred alternative(s); and indicates how these parameters contribute to increases in operational capability. In the case where a new program is approved, the AoA should be useful in limiting the number of alternatives to be considered during Technology Development. Cost and operational effectiveness comparisons, as well as appropriate supporting analyses, are documented in a written AoA report. The AoA report focuses on the critical parameters having significant impacts on capability, readiness, and cost.

During System Development and Demonstration, analytical efforts include requirements trade-off analyses, system engineering trade-off analyses, and the AoA. The Design Readiness Review (DRR) analysis assists in refining performance objectives and minimum acceptable performance levels. It considers alternatives other than the development baseline and the current system if there have been dramatic changes in mission, threat, technology, or cost. The current system continues to serve as the base case in order to permit more effective quantification of improvements related to variations in performance. The DRR analysis must be consistent with other analyses supporting the acquisition management system.

During Production and Deployment, if significant changes to mission, threat, performance, or cost have occurred since DRR, the previous AoA should be updated. In particular, this may be necessary if operational test results obtained during System Development and Demonstration are below estimates used in the DRR analysis and associated trade-off analyses. In any case, an analysis or analysis update of cost and training effectiveness should be conducted during this phase.

Applications

AoAs are required for ACAT I systems and recommended for all others. For Acquisition Category II and III the AoA should be streamlined and tailored to reflect the decreased cost and complexity of the system. Regardless of the acquisition category, all analyses required in the AoA must be addressed.

Most AoAs produce four major products:

1. A study plan which defines the background, goals, methodology, tools, schedule, etc. of the AoA.
2. A midterm progress briefing to summarize early work and future plans.
3. A final briefing to summarize the final results of the AoA.

4. A final report to document the AoA in detail.

The study plan is important because it defines what will be accomplished and how it will be accomplished. The plan should be updated throughout the AoA as changes in threat, computer models, methodology, etc. occur. The midterm briefing is designed to permit redirection of the AoA by senior reviewers if necessary. The final briefing will carry the most impact, and hence will generate the most interest. The final report is the repository for AoA information and will require significant effort to produce. Frequently, the study plan or final report will be accompanied by supporting documents providing detailed descriptions of the alternatives, threats, cost documentation, intermediate analysis results, and so forth.

Essential Elements of an AoA

- Mission Needs, Deficiencies, and Opportunities. The aims of this element of an AoA are to identify defense needs, to define the deficiencies of existing systems in meeting those needs, and to discover opportunities for satisfying needs and alleviating deficiencies.

- Operational Environments. There are a number of sub-elements that go into the operational environment. It is important to:

    - Evaluate explicitly the potential contribution of Allied forces.
    - Evaluate terrain, weather, ocean, or other pertinent environmental parameters, including atmospheric conditions.
    - Consider the operational threat environment.

- Constraints and Assumptions. Constraints and assumptions are factors that limit the set of viable alternatives to be considered. They should be carefully defined and stated explicitly. For example, the requirement for a system to be transportable on a C-130 is a constraint. The set of alternatives is limited to those alternatives that do not exceed the size and weight carrying capacity of the C-130.

- Operational Concept. A good analysis embraces a solid statement and analysis of the Organizational and Operational (O&O) Plan for each alternative.
- Functional Objectives. Functional objectives are quantitative statements describing, the system’s performance expectations.
- Alternatives. One of the most important steps in developing the analysis is to identify system alternatives.
- Models. Models are representations of an actual or conceptual system that involve mathematics, logical expressions, or computer simulations. They are used in AoAs to estimate how a particular system may function.
- Data for the Analysis. It is important to develop a validated database for the analysis. The data must be current, accurate, and technically and operationally validated by engineering assessments, technical tests, and operational tests.

Additionally, current tactical and employment doctrine must be reflected in the database.

- Measures of Effectiveness (MOE). MOEs are tools that assist in discriminating among a number of alternatives. They show how the alternatives compare in meeting functional objectives and mission needs. Range, speed, payload and reliability are examples of MOEs.
- Cost Estimates. Cost estimates are as important as operational effectiveness measures in the analysis. Cost-estimating techniques and tools are presented in AABC.
- Trade-off Analyses. Trade-off analyses describe equal cost of equal capability packages. These analyses are an important component of both Milestone A and B analyses.

Operational Effectiveness

The operational effectiveness of a system, organization, or tactic is the degree to which the ability of a force to perform its mission is improved or degraded by the introduction of the new system. Operational effectiveness should be distinguished from performance. Operational effectiveness is a force attribute, while performance is an attribute of a particular system. Operational effectiveness and performance are closely related. A new system may perform an individual task, such as firing more quickly, better than another alternative, but its operational effectiveness may not be significantly greater than the second alternative, because its introduction into the force does not produce the hoped for improvement in the force.

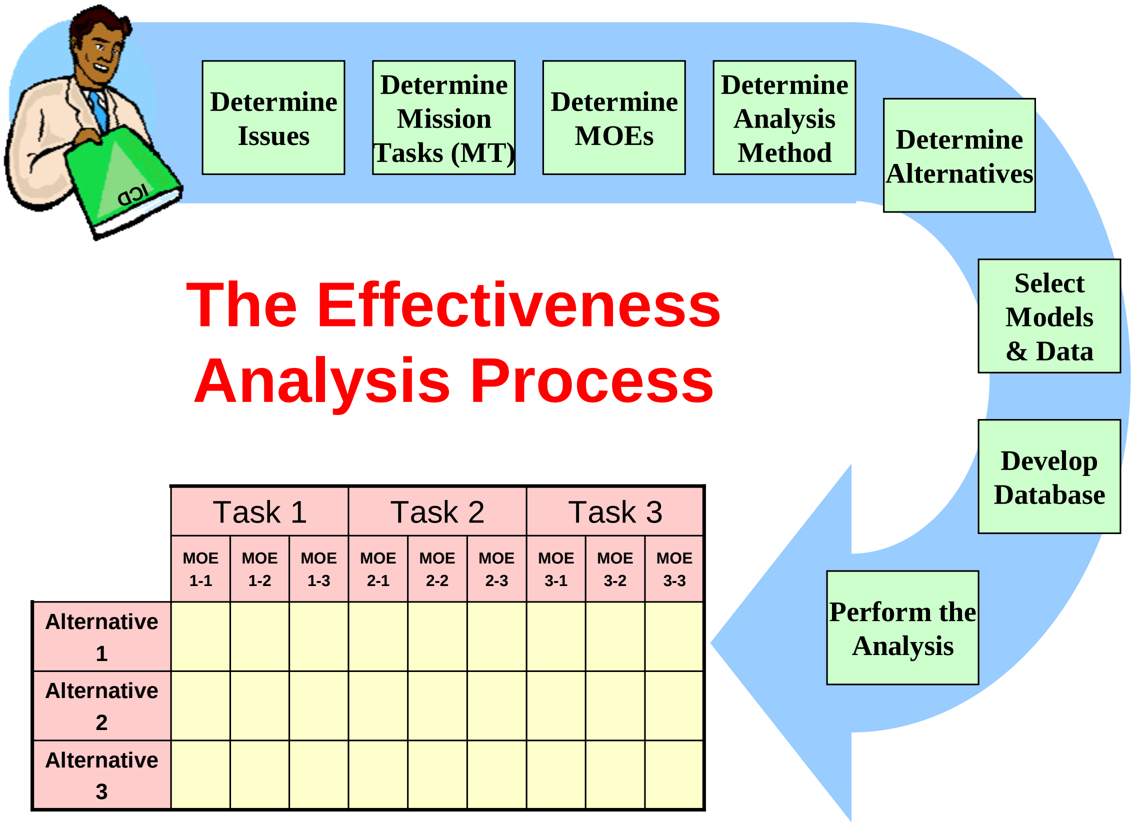
Operational effectiveness is concerned with a force. It looks to end results and is measured by MOEs such as reliability and vulnerability. These MOEs are quantified and involve a large amount of judgment in their selection and evaluation. The judgmental element is often expressed in terms of non-quantifiable attributes.

When evaluating performance, individual systems are described in depth and in terms of their performance characteristics. Performance can usually be expressed in mathematical terms, often through the use of probabilistic statements.

Planning and Execution

The development of effectiveness information is best accomplished by backward planning and forward execution.

In the first step, MOEs must be selected which can distinguish among alternatives. These measures should be selected based on the essential elements of analysis (EEA) issues that have been identified. The next step is the selection of a standard combat developments scenario and tasks which, when used in games or simulations, can produce the selected MOE. Having decided on the scenario and tasks, the analytical method (model) which can exercise the scenario to produce the selected MOE is then chosen. The method can range from a simple mathematical equation through complex simulations.



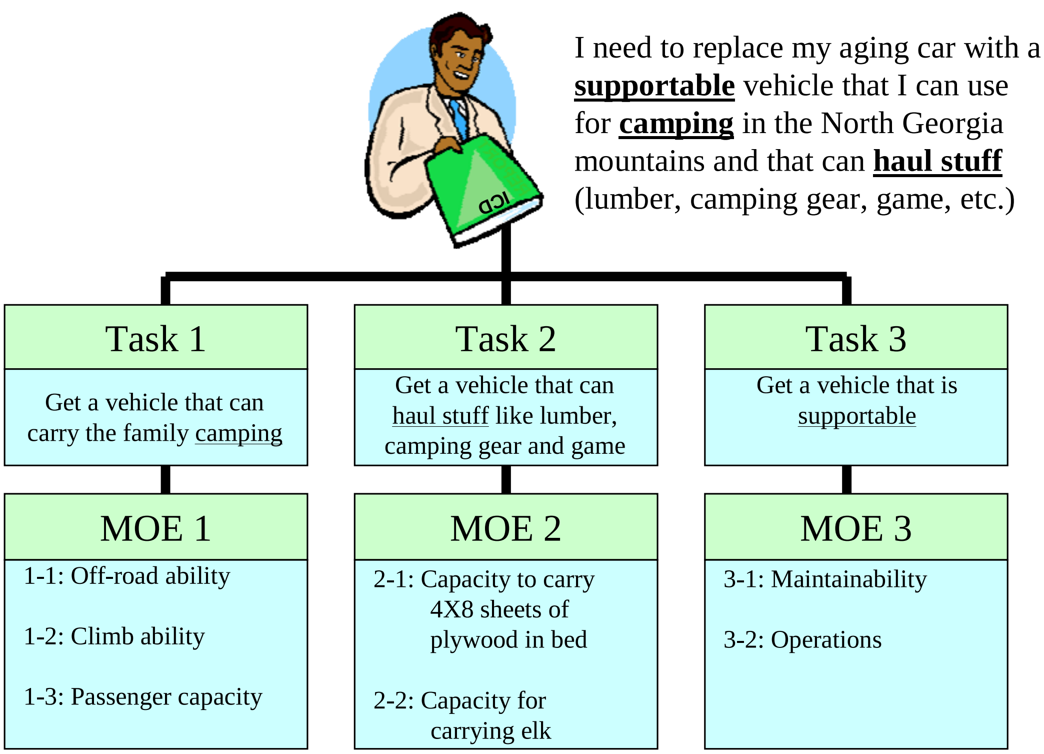
Once the method is selected, the data required to exercise the analytical tools must then be identified. Frequently, all required data will not be available. Planning for tests and experiments must be initiated to provide data which will be available when the analytical methods are ready to be exercised. The long lead time for obtaining data from conducting tests must be considered.

In backward planning, some steps can take place concurrently, but no step should be put into final form before the steps that follow it. For example, if a scenario is chosen before MOEs are selected, it may turn out that the scenario cannot provide information on the MOEs and, consequently, additional work will have to be performed.

We use a forward order to execute the plan. Here again, considerable concurrent work can take place, but as a rule of thumb, no step should be finalized before its predecessor is complete. As an example, using outdated information in your scenario may require you to repeat your work when up-to-date information becomes available.

Aspects of MOEs

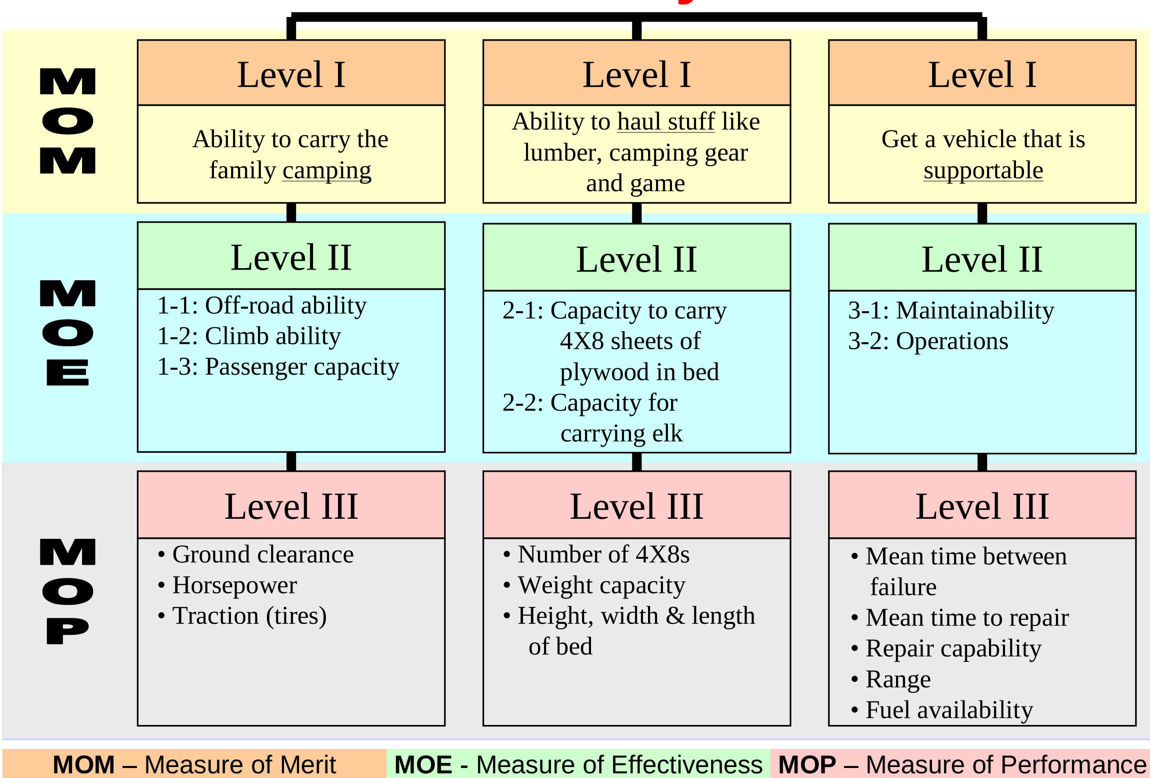
A MOE is a quantitative indicator of the ability of the system to accomplish the task for which it was designed. A MOE is used to distinguish among alternative candidates designed to perform a specified mission within the force. Selecting the MOE is a subjective process based on how the study agency believes force effectiveness may be best assessed. Its selection is the responsibility of the study agency, with analytical advice when necessary, to ensure that the particular MOE can be quantified. The MOE is expressed quantitatively by numbers usually derived by an analytical process. It must be capable of being produced by analytical tools which address the situations in which the candidates will be employed on the battlefield.



The MOE is a force attribute. It should quantify the effectiveness of the force as a whole and not be limited to the performance of the system under examination. The contribution of the system and its competitors to the operational effectiveness of the force is, therefore, measured by the change in the value of the MOE from some base case, most often the current system the replacement of which is being considered. The MOE for operational effectiveness deals with synergistic effects in which the effectiveness of the whole may well be greater than the aggregate of its parts taken separately, i.e., mines and tank guns may kill a certain number of enemy tanks when used separately, but, when used together on the battlefield, they reinforce one another, and the total number of enemy tanks killed is then greater than the sum of kills by the systems when used separately.

An important consideration in selecting MOEs is the suitability of the MOE to the appropriate decision making level. There is a hierarchy of effectiveness which is analogous to the levels of decision being addressed. In general, a MOE at one level is dependent upon one or more measures at the next lower level. The MOE for a higher level is developed by applying the measures at the next lower level. So, the MOEs at Level II, operational effectiveness, are calculated from utilizing the performance of the system (Level III MOE in a simulation, field exercise, or the like).

The Hierarchy of MOEs



The ideal MOE for all systems would be at Level I, the degree to which the system improves the ability of the force to accomplish its mission. Unfortunately, in most cases, this MOE is not applicable to operational problems, since many alternatives to a system will accomplish the force mission, and the difference in degree of accomplishment by the various candidates may become difficult to distinguish. For studies involving large forces of interest to the service, Level I measures have more application. These measures of effectiveness are typically known as Measures of Merit (MOMs).

Level II MOEs best describe operational effectiveness in high resolution examinations and are most suited for use in studies. They measure end results and measure those results in terms of the total force and not just the system under examination. Because they are end results and attempt to consider all the interactions on the integrated battlefield, they are few in number for a given study. Although it is desirable to limit the number of MOEs, sufficient MOEs should be used to properly assess the system and they should be suited to the needs of the system. Measures of effectiveness at this level are simply referred to as themselves, MOEs.

Where it is not practical to determine end results, such as in the examination of a Corps communication system where determination of direct relationship between communication and combat units could be complex and expensive, it may be necessary to use Level III MOEs. Level III measures are based on performance characteristics. As an example, in a Corps communication study, Level III factors were employed since Level II factors could not be used. It took 60 factors to properly measure the communication system. The impact of communication on the result of battle could not be measured directly. Therefore, it was assumed that the communication which was most effective when compared on a system to system basis would be the most effective on the integrated battlefield, which might not be true, or at least the difference would not be as great, as that developed from examining only Level II MOEs. We typically use the term Measures of Performance (MOPs) when referring to Level III MOEs.

Level IV factors are of primary interest to technical people concerned with hardware development. They contribute to the determination of performance factors, but they are rarely, if ever, suited for use as MOEs in an AoA.

In any analysis, in addition to MOEs, a large amount of numerical data of interest to the study will be produced. This data will frequently be of a Level III type in that it will indicate the factors which produced the MOEs. Typical information of this type might be "kill rates per sortie," "time to first acquisition," "detection rates," "number of rounds fired per engagement," or "time unit suppressed." This information is frequently confused with true MOEs, but it does not meet the requirement of depicting end results. It will assist in making decisions on ranking of alternatives when the basic MOEs do not give sufficient insights into system differences.

In some cases, a study may not produce quantifiable measures - MOEs which are completely responsive to the study needs. In that case, resort must be made to judgmental evaluations on the basis of non-quantifiable, but still important, system attributes. The attributes will be used by themselves or with MOEs to analyze the system. Non-quantifiable attributes will be of particular value when MOEs fail to differentiate between two systems. As an example, two aerial rocket systems when analyzed using the MOE "friendly casualties" may give about the same answers. Since these systems have a mission of suppressing enemy forces, it would be desirable to use "suppression" as a MOE. Unfortunately, no totally acceptable way has been found to quantify suppression in this situation. Accordingly, a judgmental assessment must be made. This assessment could be made on the basis of field tests, questionnaires, experience, or some ordering system.

The MOEs generally suitable for operational studies, particularly those of high resolution, were identified as being Level II factors in our hierarchy. While the number of MOEs should be fitted to the study needs, the fact that a study is concerned with end results permits the use of far fewer MOEs than would be needed if it were concerned with Level III factors.

Some type of enemy casualties, either materiel or personnel, is almost always a good MOE, since starting enemy forces normally remain constant, while starting friendly forces may be varied to assess the effects of the alternatives under examination. All action on the battlefield, whether it is improved detection or accuracy, new tactics, logistics factors, or any other significant variable, should affect the number of enemy casualties, since the enemy is doing everything possible to thwart the accomplishment of the friendly force mission. The fact that this MOE can be simply applied should not detract from its usefulness. In order to use enemy casualties as a MOE, the enemy force must be sufficiently large, so that it will not be destroyed quickly, thus preventing discrimination between alternatives. In some cases, enemy survivors may be used instead of casualties, but the principle on which the MOE is based is the same.

Friendly casualties is a MOE that is widely used, especially in connection with introducing large, expensive hardware items. This MOE should address end results and not only effects on a single hardware system. Friendly survivors may be used instead of casualties.

Rate of advance is an MOE that, although more difficult to apply, may be very useful in analyzing mobile warfare. It has the drawback that if both friendly and enemy forces have very heavy casualties, the friendly force may still be able to advance rapidly and seize its objective, even though it may not be fit to continue to fight. In some cases a multiple MOE combining rate of advance and casualties of some type might be used in your study.

Time factors may be used as a MOE. In an attack, the time for a force to seize an objective or reach an analysis point may be a MOE. It is really a variation of the rate of advance, but is easier to determine. In defense or delay, the time a force can hold a position or execute a delay may also be a suitable MOE.

Weight of ammunition expended is a logistic measure that may serve as a MOE for a combat analysis, particularly when firepower considerations are paramount. Since the ability to continue to fight may depend on the rate at which ammunition is expended, and since some weapons may require heavy ammunition expenditure, this measure can be related to combat results.

Frequently, a single MOE may be composed of factors which are not all equivalent. This type of MOE is called a complex MOE. As an example, if the MOE selected is "enemy casualties", it may be desirable to break these casualties into categories, such as "dismounted personnel," "light armored vehicles," etc. Individual elements of these categories are not equivalent; their value to the commander would vary from situation to situation. There is no simple method for equating or combining these factors into a single number in order to quantify the overall effectiveness of a force. Resort must be made to detailed analysis, weighting, rankings, judgmental evaluations, or to some combinations of all of these.

Many times neither a single simple MOE, nor a single complex MOE will suffice, you must resort to using a multiple MOE, even when Level II effectiveness can be used. A study evaluating cavalry or scout units may require, as MOEs, both friendly and enemy casualties, and additionally require delay times to permit analysis of one of the principal missions of reconnaissance type forces. As in the complex MOE, there is usually no direct way to convert these multiple MOEs into a single number for analysis. The same means of combining the various quantities may be used for a complex MOE. Some situations demand multiple MOEs, some of which are also complex. Multiple MOEs may be used when it is impractical to develop Level II effectiveness; hence, Level III factors must be used. In this event, it is often found that a large number of MOEs must be used to describe the system.

When multiple and complex MOEs are used, there should be some way of integrating them in order that they may be used to rank other alternatives. Many of these methods require judgmental inputs which may not be consistent or objective.

The first attempt in handling complex or multiple MOEs should be to determine whether all factors are really affording a measure of the effectiveness for the various systems examined. If not, it may be possible to eliminate all but one, thereby condensing the complex or multiple MOEs to a simple MOE. For instance, even though the MOE is "enemy casualties," it may be found that battle outcome in a particular study is consistently related to the number of enemy air defense weapons destroyed. It may then be possible to eliminate other factors, so that the MOE would now become the single quantity "enemy air defense weapons destroyed." Quantified information on casualties to other enemy weapons should be a by-product of the principal effort and could be used in different analyses.

Weighting may be used to combine multiple or complex MOEs. Weighting is essentially a judgmental process in which a relative value is given to each system under examination according to its assessed value on the battlefield. Although weighting is widely used and may often be the only way of resolving a study in which different MOEs measure the effectiveness of different candidates, it should be avoided when possible, and used with care if there is no other alternative. Numbers, even when judgmentally assigned, tend to take on the aura of fact, and the factors prompting the judgment are soon forgotten. The use of weighting assumes that meaningful quantitative relationships between MOEs can be developed subjectively, which may not be true. It is possible in some situations that rate of advance is more important than enemy casualties, but to weight one at twice the value of the other requires a rationalization which may not be possible to demonstrate. In any event, if weighting is used, the output of the analysis should permit determination of the degree to which assigned weights influenced the outcome (whether they did so in a logical manner) and how sensitive the results were to changes in weights.

Weighting with Similar Units

MOE - Enemy Tank Losses

- Three Systems.
- MOE in Attack and in Defense:

System	Attack	Defense	Ranking
A	2.2	2.0	4.2 = 1st
B	2.0	1.5	3.5 = 3rd
C	1.0	3.0	4.0 = 2nd

Multiple MOEs may be weighted with similar measurement units. In discussing this situation, consider the case where a single MOE, "enemy tank losses" is being used. If both attack and defense are being considered, it may be decided that tank losses by an enemy attacker are twice as important as similar losses to an enemy defender.

Weighting with Similar Units

MOE - Enemy Tank Losses

Defense Weighted at 2.0 and Attack at 1.0

– Three Systems.

– MOE in Attack and in Defense:

System	Attack	Defense	Ranking
A	2.2	4.0	6.2 = 2nd
B	2.0	3.0	5.0 = 3rd
C	1.0	6.0	7.0 = 1st

Weights 1 and 2 are applied to the casualties assessed by three systems, A, B, and C. Then system C has the highest MOE, even though it was poorer than the other systems in the friendly attack. More complicated weighting systems could be used if scenarios were used for each tactic, but the greater the number of factors weighted, the more difficult it would become to identify the influence of the weightings assigned.

Weighting with Different Units

MOEs - Enemy Tank Losses
Rate of Advance

System A represents our current system, so we want to put the other Systems in relation to it…

System	Enemy Losses	Rate of Advance
A	9	8 mph
B	8	7 mph
C	12	6 mph

The method of weighting multiple MOEs with different measurement units applies when two MOEs do not have the same standard of measurement; for example, numbers of enemy tanks killed and rate of advance of the friendly unit in miles per hour. In this case it is necessary to convert the MOEs into dimensionless quantities, and then apply weighting factors.

Weighting with Different Units

MOEs - Enemy Tank Losses
Rate of Advance

…For each MOE, Divide by the values for System A, then consolidate.

System	Enemy Losses	Rate of Advance	Ranking
A	9/9=1	8/8=1	2.00=2nd
B	8/9=.88	7/8=.88	1.76=3rd
C	12/9=1.33	6/9=.75	2.08=1st

The dimensionless quantities are produced by dividing each MOE by the lowest MOE value achieved by one candidate, usually the base case. This process is called "normalizing." Normalization is usually performed around the base case, which has the value of one for all MOEs. This is not the normalization usually expected in the strict mathematical sense, i.e., there is no relationship to normal distributions implied in the use of this term.

Weighting with Different Units

MOEs - Enemy Tank Losses
Rate of Advance

Enemy Losses Weighted at 2.0 and Rate of Advance at 1.0

System	Enemy Losses	Rate of Advance	Ranking
A	2	1	3.00=2nd
B	1.76	.88	2.64=3rd
C	2.66	.75	3.41=1st

When the study examines an integrated battlefield, it is not always possible to express MOEs in terms of a single system, such as "number of enemy tanks killed." It may be desirable to know the total effect on the battlefield when every element has some combat value and hence every casualty contributes to force effectiveness. Weighting in this case may be done by assigning to each element of the battlefield a military worth, a dimensionless quantity which can measure the military worth of all systems on the same standard. Consider an evaluation to be performed by firing the candidate systems at the same group of enemy targets taken from a snapshot of the integrated battlefield. Military value might be assigned in an amount similar to that shown in the slides below

Military Worth

System A

Item	Value	#Killed	Total
Rifleman	1	16	16
Small Unit Leaders	2	4	8
Machine Gun w/Crew	5	4	20
BMP	27	16	432
BMP w/ATG	37	4	148
23mm Air Defense Weapon	37	4	148
T-80 Tank	37	8	400
TOTAL			**1,172**

Military Worth

System B

Item	Value	#Killed	Total
Rifleman	1	27	27
Small Unit Leaders	2	5	10
Machine Gun w/Crew	5	4	20
BMP	27	12	324
BMP w/ATG	37	4	148
23mm Air Defense Weapon	37	4	148
T-80 Tank	37	8	400
TOTAL			**1,077**

The total number of each target killed is summed at the end of the battle, multiplied by the military worth, and the resulting sums added to produce the consolidated MOE for the particular system. In this example, although the force with system B is as good or better than the force with system A against all enemy weapons systems except the BMP, the weighting factor for the BMP was decisive in giving system A better MOE results than system B. Such a distinction should be accepted only after considering all study factors.

A variation of weighting by assigning military worth is the Force Effectiveness Indicator (FEI). At the start of a battle, weighting is applied as we discussed before. As the battle progresses and kills occur, the military worth of surviving weapons is upgraded.

In dealing with complex MOEs, efforts have been made to use the dollar cost of friendly casualties as a MOE. This method is actually a weighting system, in which the weights are equivalent to the cost of the system. It is a weighting method to which no judgment has been applied. This weighting method can be misleading, and should be avoided, since effectiveness is not necessarily a function of unit cost. Similar attempts to develop dollar costs of enemy systems as a MOE can be even more misleading, since the cost to each country of developing systems cannot be equated by currency value.

The difficulty of maintaining objectivity and consistency in assigning weights to obtain single MOEs has already been discussed. When you are using complex or multiple MOEs, keep the factors separate. Afterwards, you can make a judgmental evaluation on the resulting MOEs. It is well to keep in mind that a judgmental evaluation offers an important and attractive alternative to weighting.

Selection of MOEs is one of the most critical steps in analysis. This paragraph indicates criteria for selection of MOEs and summarizes what has been discussed previously.

- The MOE should reflect the contribution which a system under study makes to a force.
- Selection of the MOE is the responsibility of the military proponent.
- The MOE must be capable of being expressed numerically, preferably on a ratio scale.
- The MOE should reflect battle outcome.
- The fewer and simpler the MOEs, the more positive the analysis.
- If multiple or complex MOEs must be used, attempts should be made to relate them judgmentally rather than by weighting.
- If weighting must be used, then simple methods should be preferred to complex ones. Dollar costing of loss as a means of weighting is unacceptable.

Scenarios

Scenarios are selected to give a valid picture of the battlefield on which the systems being analyzed will play a significant role. They are selected from standard combat development scenarios, and they should be used unmodified if possible. Where the system introduces new operational or organizational concepts not included in standard scenarios or which information is needed which may not be available from standard scenarios, they may be appropriately modified after approval by the service.

Scenarios should avoid bias either for or against a system. Biases that cannot be avoided should be identified. Scenarios not only cover troop dispositions, but also tactics of friendly and enemy forces. The tactical aspects of the scenario may be critical to the study. Extreme cases should not be played, or if played, should not be played alone but compared with more frequently occurring situations. Use of extreme cases could yield information on the range of results and indicate how sensitive the problem is to choice of scenario. Enemy forces should be portrayed objectively. To the extent that resource constraints permit, several scenarios should be exercised using several different terrain types, weather and obscuration factors, and different tactical postures, such as attack and defense.

The scenario should be a realistic portrayal of what the alternatives may encounter and should picture the way they can best be used. If tanks are being examined, the comparison should not be based solely on gaming in swampy ground. If air defense weapons being examined have a top altitude of 60,000 feet, there is no point in a scenario in which threat aircraft always fly at 100,000 feet. A scenario which requires that area weapons designed for use against soft targets attack hard targets will yield no meaningful MOE.

A scenario should be designed so that it can have a range of outcomes, thereby permitting comparison of alternatives. If a situation is portrayed in which a friendly force initially cannot hold a defensive position, and it is permitted to reinforce until the position can be held, the potential reinforcements should cover a wide spectrum, such as tanks, air defense weapons, close air support, or even whole units. If the reinforcement is restricted to a few systems, then all logical alternatives may not be considered.

Models and Other Analytical Tools

The analytical tools that exercise the scenario to produce MOEs are the most technical aspect of studies. They should not, however, be left exclusively to the operations research analyst, since the way in which they produce results can profoundly affect the MOEs. The analyst and military proponent should work together. The military proponent should be sure that the nature of the analytical technique is understood. The proponent need not comprehend all the mathematical relationships involved, but neither can the assumptions, limits, aggregations, and unrealities of the tools which will provide the data on which to reach a decision be ignored. The military proponent should participate in the selection of analytical tools, keep current on them, and act as a liaison between the analyst and the ultimate decision maker.

There are a variety of analytical tools available to support a study. These tools are employed to reduce time and resources in the examination of a problem. As might be expected, those which furnish the best data are most demanding of resources and time.

A model is a representation of the real world and produces numerical output which can be related to real world actions. Models supply information to the decision maker. Unless the decision maker wishes to abandon the role to the analyst, what the model does and how it does what it does must be understood. The black box concept of models should be avoided, although the same level of knowledge is not required of the decision maker as of the analyst. On the other hand, no model is real, since all depart to some degree from actual combat. A model is real enough if the decision maker, reinforced by staff advisors and personal experience, can use the model output understandingly to help make a decision.

Models should be selected to meet the study schedules and the resources available to conduct the study. Models which require long lead times should be used sparingly. Model modification to meet study needs should be avoided, if possible, through adjustments in the scenario or its database. This approach is frequently not possible since much of the use of models is to explore new materiel, doctrine, or organizations.

Models must be able to exercise the scenario selected and to produce MOE data. If a reconnaissance unit is being examined, the model must be able to play withdrawals, delay actions, and mobilize defense. A model designed to examine artillery systems where the MOE is a percentage of all targets killed by artillery must be able to analyze lethality of the ammunition against such targets as moving tanks. MOE data must be produced by the model by logical methods based on sound military tactics. The model must demonstrate a cause and effect relationship understandable to the proponent. This is often accomplished by a battle history which gives an event by event description of what occurred.

Characteristics of the model or models selected to support a study which can have a profound influence on the MOEs are resolution, realism and responsiveness. An ideal model would nearly approach real world actions, have resolution to the individual soldier, and be capable of being made ready and exercised in a few days. These requirements are competing and compromises may be necessary.

Resolution is the detail to which the models play the force under consideration. Resolution may vary from low to high. A greater degree of resolution implies detailed examination of the system. This resolution goes to the number of individuals or things played and the detail to which they are played. One model plays tanks moving across terrain at a single average speed; a higher resolution model may adjust the speeds to the terrain, environment, and tactics of the user. As the resolution becomes greater, the model becomes more complex and the resources it requires become greater. High resolution models usually examine units of battalion size or lower and are almost a necessity for examination of weapons systems. Output from high resolution models can be very useful by data reduction and synthesis, but require time. If many alternatives with multiple scenarios and tactical missions must be examined, time may not permit complete use of high resolution models. Therefore, the level of resolution selected should be only as high as required to address the questions in the study. One solution may be to use high resolution models for principal MOE data, while models of less resolution are used for rapid excursions to examine sensitivity of the systems to variations in characteristics and environment. Larger forces may be examined by models of lower resolution, since some consolidation of units and times can be accepted for forces, such as divisions which have thousands of elements and operate over long periods.

Bound up with the idea of resolution is the size force being examined, the larger the force the greater the problems of obtaining high resolution. Yet the aggregation in models of units of even division size may be so great as to distort results to an unacceptable degree.

A second approach is to exercise high and low resolution models in the same scenario. The high resolution model looks at weapon performance, detailed organization, and tactics, while the lower resolution model looks at logistical support and area communications. The results of the two models are then subjected to a judgmental evaluation, which produces overall conclusions about the systems being examined.

In an attempt to cope with resource problems, models often play the pure or at least the incomplete battlefield.

Model responsiveness is considered from two aspects: speed of preparation and execution time, and adequacy of information to respond to questions in the study. These two aspects of responsiveness often conflict; the shorter the time for preparation and execution, the less information the model is likely to develop. A compromise may be worked out in which a combination of models is used; a model of higher resolution for in-depth information and a more aggregated model to cover a wider span of variation.

All models depart from the real world. Recognizing this limitation, models should be so constructed that they can at least give insights into the situation being examined. Since they cannot exactly reproduce the real world, they should provide such a good parallel to the real world that they can be understood and used by the military proponent. Time and resources play an important part in the degree of realism which can be incorporated into a model.

Battlefield coverage involves the evaluation of force on force models versus the pure or functional model. Ideally, all systems should be examined in the complete military environment in which they will be employed. The degree of resolution, number of elements required, scarcity of data, and sheer complexity of the effort often make complete realization of the goal unattainable. In an attempt to cope with resource problems, models often play the pure or at least the incomplete battlefield. When tanks are being examined, models may play tanks and antitank weapons, but the influence of dismounted infantry on the battlefield may be ignored. In large models, the need to cut down numbers of elements may produce a pure battlefield. A model to examine corps or division artillery may ignore the casualties produced by other friendly weapons or aggregate them to a degree that their effect on the enemy and on the artillery effort is not clearly portrayed.

Unless the integrated battlefield is played, the model cannot to realistically portray the impact of new systems. Efforts have therefore been made to include more realistic play of combat into all models by incorporating all the forces which would be expected to be present. Models which once played armored warfare as strictly a tank antitank battle now include artillery, communications, mines, and aircraft. The models have become complex and the running times longer, but they have provided an increasingly realistic picture of combat. Much remains to be done in the area of model improvement. Areas of primary interest are the modeling of the integrated battlefield which can play both mounted and dismounted forces, nuclear, and chemical warfare and degraded observation. A model which plays the complete battlefield should be the primary choice to support any study. Pure models should be used only when their use is dictated by time and resource constraints, and the biases which they introduce should be carefully assessed.

Dynamism is an important element of reality. A dynamic model is one in which for each action of an element on one side, there is a logical reaction on the other. It is a model in which command and control have been automated by use of decision rules and templates so that military type orders can be input into the model initially, with no further intervention needed, and without the need for inputting detailed orders.

In a dynamic model, if blue fires at red, red ducks. If red defenders can observe an area, blue attackers avoid it. The attacker varies the route in response to enemy fire, casualties, or enemy casualties. The dynamic model is a good parallel to the real world. A dynamic model is best played using probabilities, so that a number of runs for each situation must be used. Dynamic models for the computer originally posed so many technical problems that non-dynamic models were used. In a non-dynamic model, one in which command and control have not been automated, the actions to be taken by each side are put into the model in advance in the form of preprocessors or by use of specific orders to each element with few contingencies. The lack of action and reaction by the forces impose serious limitations on non-dynamic models in relating their output to the real world.

With the advance of modeling techniques and advances in computer technology, dynamic models for the computer have been developed. They operate on the basis of decision rules which are a part of the model program and are applicable to any element at any time in the battle. As might be expected, they are quite complex and long running on the computer, but the amount of realism which they add to the play makes them preferred models when constraints permit their use.

The players in map exercises and war games with computer assistance replace the command and control routines of the fully automated model. Human beings give considerable flexibility to models, but such models are not responsive and they are resource intensive. Map exercises and war games may be used to develop data on tactics, doctrine, and organization for input into more sophisticated models.

Models aggregate the terrain and some compromise with the real world must be met. Maps themselves offer an understandable approximation but even they are frequently too detailed for use in any models which employ automation. The terrain must be related to command and control and the way units move.

The geometric terrain is an aggregated concept most useful for low resolution models. Each cell is coded for terrain characteristics. Movement is essentially from the center of one cell to the center of another. This type of terrain approximation is not restrictive and can be used in dynamic models.

The corridor terrain is constructed of cells similar to geometric terrain, but they are not of uniform shape. Units are restrained to move vertically up and down the corridors, but cannot move cross them. The corridor terrain, therefore, is also a means of inserting command and control into the model. Obviously, a model using this type of terrain lacks flexibility when it is compared to other terrain alternatives.

The digitized map is a fairly accurate representation of the actual map. Digital maps tend to have a leveling effect on the maps they represent. They are prepared by picking off points which form a grid that is superimposed on the actual map. The grid is smaller when nearer the approximation to the map, but the amount of detail which must be sorted in the computer is greater. Digitized terrain is preferred for high resolution models.

As much as 50% of the calculations in a high resolution model may be required to determine line of sight. The elliptic terrain is designed to greatly reduce this percentage. All elevations are represented as ellipses which results in a considerably faster line of sight determination. It is designed for high resolution models. Because the terrain has an artificial appearance, the elliptic approach has not won high acceptance.

Networks are used for logistics modeling when cross country movement is not anticipated. They are adequate to these limited purposes, but are unsuitable for more extensive use.

In probabilistic terrain, which is based on a computer analysis of maps and on some of the ground tests, the probability of line of sight between any two points within an area is developed. When used in the model, random numbers are drawn against the probability with line of sight in each case determined by the result of the draw.

A model must be able to assess a situation over time. It is not possible in automated games to evaluate a continuous time as in the real world, so some action may be taken to deal with time in increments. Two approaches, event sequencing and time sequencing, have been developed and are depicted below.

In event sequencing, each event is given a start time and a means of determining where it will end. For instance, a firing event may end when the round is on the way. When the particular event ends, the element is then assigned a new time and goes into the time queue. The event with the next start time then takes place. This sequence is repeated over and over throughout the game. Event sequencing allows proper modeling of the event and a high resolution examination.

In time sequencing the battle is divided into time steps and all happenings are presumed to occur at the end of each step. Assessments are made by sophisticated mathematical techniques. This method is used in models for low resolution and favored in deterministic simulations.

There are several types of models available for use; resolution, responsiveness, and realism enter into each of them.

Mathematical models can often be prepared by an analyst at their desk or with a small amount of computer support. Mathematical models generally aggregate the actions which they examine or else examine in detail very limited aspects of the battlefield.

The detailed examination may be used as input to models of high resolution. Mathematical models of a force are expected value or deterministic models, that is, they consider that over many situations a probability is equivalent to reality. They are static, and make gross assumptions about many aspects of the battlefield. They cannot be expected to give a complete picture suitable for decision making. They can, however, serve important functions if used to supplement the output of models of higher resolution. They may also be employed if there is no other suitable model available to support the study within time constraints. The output of the mathematical model can be successfully used if its limitations are understood by the military proponent. Model limitations should be listed any time mathematical models are used.

Mathematical models are highly responsive, have high resolution for restricted coverage but low resolution for a force, and may not be very realistic in terms of the needs of the decision maker.

The deterministic model is also an expected value model. It is a sophisticated extension of the mathematical model to a force, which incorporates terrain considerations, higher degrees of resolution of elements, and periodic examinations of the situation with time, permitting update and more detailed examination than is possible in a pure mathematical model. It becomes a practical model because of the computer. Model play is broken into a series of small time steps, and the situation of the forces is updated for that period. A considerably greater insight into an operational situation is possible with a deterministic model than with a pure analytical model. The deterministic simulation can be viewed as a series of analytical models which are constantly updated to meet a changing situation.

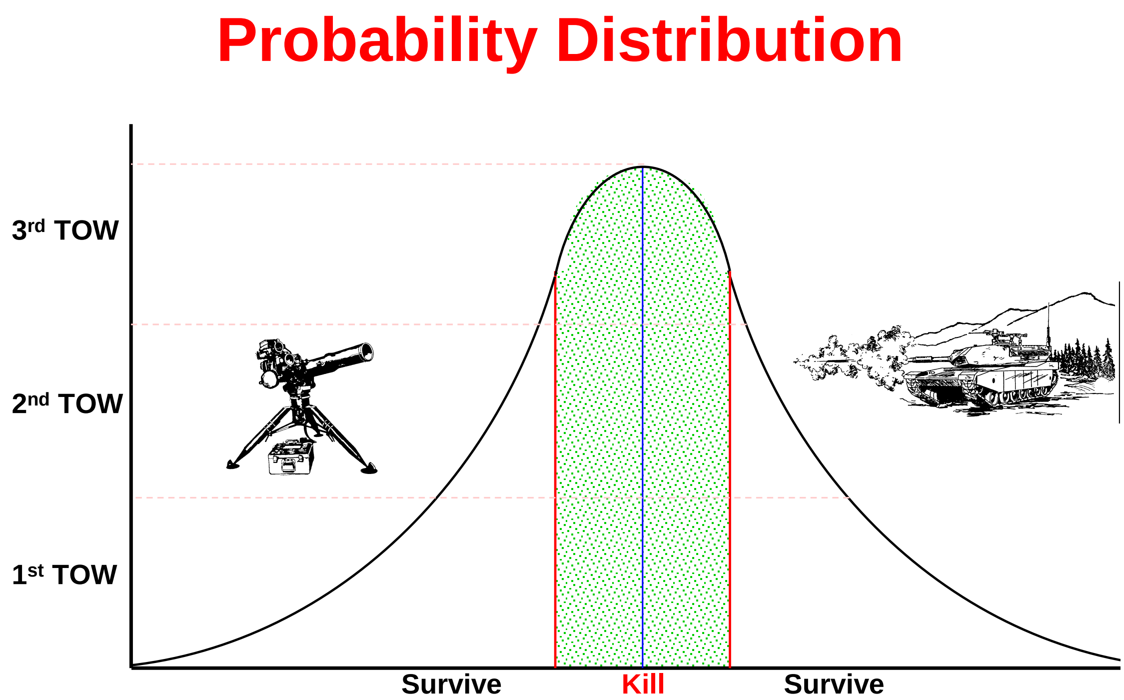
Since the deterministic model uses expected value rather than probabilities like the mathematical model, no distribution is produced. For a given initial situation the deterministic model will always give the same answer in terms of MOEs. Deterministic models are widely used to examine large units, such as division, corps, and theatre. They are less widely used for high resolution models.

The use of a high resolution deterministic model is limited. A battle history can be printed, but it may be difficult to relate it to the military user because portions of individuals can be killed and the remaining portions continue to operate. If a TOW fires at a complete tank, it will kill 0.3 of that tank if the expected value of a TOW shot is 0.3 at the given range. The tank will continue to operate with 0.7 remaining.

In low resolution models, the elements examined are usually aggregated units of company, battalion or larger size. These units can suffer fractional casualties which can be related to the real world. The low resolution deterministic model has been accepted by decision makers; in fact, most automated models for division or larger units are deterministic.

The deterministic computerized model has good responsiveness. It is well suited for analysis of large units, but in high resolution analysis it is lacking in ability to convey its results to the military decision maker in understandable terms.

The **probabilistic or stochastic model** plays the probabilities which occur in the real world usually by means of the Monte Carlo technique. When an event occurs, such as the probability of hit of a target by a weapon, a random number is selected. If it's within the range of the probability, the event is considered to occur; if outside, then the event does not occur. If the probability is 0.3 that a TOW can kill a tank, then each time a TOW fires at a tank, a random number is pulled from tables set up for that purpose. In this case if the selected random number is 0.3 or less, the target is considered to be killed. If the number selected is greater than 0.3, the target is considered to have survived. Whole elements are killed, the partial elements of the deterministic model are eliminated, and the battle history conveys real meaning to the military user.



The probability that a TOW shot will kill a tank is 33% (one in three)

The probabilistic model gives the user the opportunity to understand how the system under examination will behave over a series of situations. If thresholds or break points are established, the user can learn how often the system will fail to meet these thresholds, which may give a basis for eliminating several candidate systems and permit the user to focus on those systems which are producing the greatest effectiveness.

Although the probabilistic model has this great potential, it is frequently not realized. Instead, the MOEs of all replications of the model are averaged for a particular candidate, and the result is used as an MOE. This procedure produces the same type of information which can be gained from a deterministic mode. More useful information is gained from the probabilistic model, and the distribution is used as the basis of the analysis.

The probabilistic computerized model requires about the same setup time as a deterministic model of equal complexity, but it requires considerably more computer time - up to 30 times more depending on the degree of precision desired from the total model output. Computer time is an important consideration, but the total time to obtain model results is usually a function of data gathering and setup time. The time consumed in the computer processing adds a relatively small percentage to the total time. Therefore, the advantages of probabilistic models for high resolution examinations usually more than counter the disadvantages of added computer time.

The computerized models of the integrated division battlefield at the Division and Corps level can pose difficulties because of the problems in application of command and control. With larger forces, the choice is often between using computerized models and manual war games.

The manual war game has a long history and was used successfully by the ancient Romans and the Chinese, as well as by modern armies. While computerized simulations are often preferred for high resolution evaluations at the battalion and lower levels, even at these levels manual war games have considerable use for examining operational matters. They are important analytical tools for examining large forces. The assistance available from the computer has eliminated much of the drudgery from manual war games and speeded them, but those games which produce convincing results are still large users of manpower and time. Accelerated games, which can play a day of division combat in one or two days of game play, have been developed and can be used for getting generalized information rapidly.

Manual war games require a knowledgeable player staff, analytical support, an installation to house maps and permit analysis, a set of rules, and computer access. When these are available, they can produce a high resolution examination of large forces. Some manual war games use inputs from high resolution Battalion models, while in others, the Division game is conducted as the Division Commander might see it, with variations within the division dependent upon the situation of each individual unit. Because of its size, computer routines which support the manual war game are deterministic which is quite acceptable for larger forces. The complete manual war game with computer assistance can be regarded as a probabilistic model, since the play will not always interact in the same way with the computerized routine.

The player constitutes the command and control function of the forces being played. Because of the presence of human players, decisions can be made rapidly and with sound and comprehensive military knowledge. The elimination of players from automated models requires the substitution of a series of decision rules, which require complex modeling and programming and are still not able to completely represent the broad and flexible application of military knowledge to combat decision making. It is for this reason that manual war games are used in spite of the demand on resources and time.

The key factor in the manual war game is the group of selected military players who, within the rules of the game, take their actions in a logical manner, based on the combat situation being gamed. The manual war game is dynamic and possesses a high degree of realism. Most high resolution models play short, high intensity battles. The manual war game plays several days of combat, and hence can show the effects of the candidate systems under sustained operations. For this reason, it can also show the impact of logistics on battlefield operations. One of its greatest values is examining the impact of constraints. As an example, scatterable mines may look good in a high resolution simulation, but in a manual war game they may not show up as well, due to non-availability of artillery to deliver them. Since manual war games do take so much time, they should be included in a study only when long lead times are available.

Manual war games have low responsiveness, but they have a high degree of resolution considering the echelon they are addressing; they are the most realistic of all analytic techniques, not requiring a field effort.

Field tests and experiments cover everything from one-on-one duels to Division and larger exercises. From the standpoint of a study, their principal value is as sources of data for input into models and analyses. They are, however, models in their own right, and may be used to generate MOE, which can be combined with costs in the same manner as can output of simpler models. As models, field tests and experiments are time consuming and involve great quantities of resources.

While we ordinarily do not think of actual combat as being in the same class as the analytic techniques previously discussed, it is actually the best source of data. Review of military history can furnish doctrinal insights which have application to current and even future warfare. Whenever combat actions are taking place, much data can be gathered and introduced directly into analysis. While active combat cannot be scheduled, and real world difficulties impede collection of data, where it can be observed, it is obviously the best source of information on which to base an analysis.

Experience is an excellent source of data, particularly for use in models. Like field tests and evaluation, it can also serve as a direct source of MOE. Experience data suitable for inclusion in a study is gathered by means of questionnaires, which are useful analytical tools when properly employed. Questionnaires see both judgmental and quantitative information. The judgmental information can be valuable for assisting in the many judgmental evaluations which form part of the study. This quantitative data should be approached with care. Measures of times, distances, etc., tend to be only estimates of what actually happened. Even though several thousand questionnaires may be circulated and numerical answers averaged, the validity of the answers is not necessary established. Techniques to refine estimates of this type are employed, such as the Delphi Technique, but are generally inadequate by themselves to permit quantitative MOE in the definition needed in a study

Review Questions

1. What are the two uses of the AoA?
2. What systems require an AoA?
3. What is the role of the:
    a. OIPT?
    b. WIPT?
    c. Study Performer?
    d. Study Advisory Group (SAG)?
    e. Functional Proponent?
4. What is the scope of the AoA work effort in Concept and Technology Development?
5. What is the scope of the AoA work effort in System Development and Demonstration?
6. What is the difference between performance and effectiveness?
7. How is operational effectiveness measured?
8. What is modeling?
9. What are the modeling techniques that are applicable to operational effectiveness analysis?
10. What is a Measures of Effectiveness (MOE)?
11. What are the three levels of MOEs and how do they relate to performance characteristics, operational effectiveness, and the ability of a force to accomplish its mission?

Categories of Acquisition Programs and Milestone Decision Authorities[1]

Program Category	**Program Management**	**Primary Criteria ($ = FY 96 constant)**	**Milestone Review Forum**	**Milestone Decision Authority**
ACAT I				
ACAT 1D	PEO/PM	more than $365M RDTE more than $2.190B Proc	DAB (Members)	USD (AT&L)
ACAT 1C	PEO/PM	more than $365M RDTE more than $2.190B Proc	ASARC (Members)	AAE
ACAT 1A				
ACAT 1AM	PEO/PM	excess of $32M single year excess of $126M total program excess of $378M total life-cycle costs	DoD MAISRC	ASD(C3I)
ACAT 1AC	PEO/PM	excess of $32M single year excess of $126M total program excess of $378M total life-cycle costs	Army MAISRC (Members)	Army CIO
ACAT II				
ACAT II	PEO/MAT CMD CDR[aa]/PM	more than $140M RDTE more than $660M Proc	ASARC	AAE
ACAT III				
ACAT III	PM	High visibility, special interest (includes AIS)	IPR (Members)	PEO/MAT CMD CDR
ACAT IV				
ACAT IV	Systems Manager, or equivalent	All other acquisition programs (includes AIS)	IPR	MAT CMD CDR[bb]

Notes:

[aa] MAT CMD CDR is PEO-equivalent level commander of a materiel developing command. MDA authority may be further re-delegated at the materiel command commander's discretion no lower than a GO/SES level. Re-delegation will be forwarded through channels to the ASARC Secretary (SARD-ZBA).

[bb] MDA authority may be further re-delegated at the materiel command commander's discretion. Re-delegation will be forwarded through channels to the ASARC Secretary (SARD-ZBA).

[1] Extract from *DODI 5000.2*.

Abbreviations and Acronyms

AAE	Army Acquisition Executive
ACAT	Acquisition Category
ADM	Acquisition Decision Memorandum
AMC	Army Materiel Command
AMSAA	Army Materiel Systems Analysis Activity
AoA	Analysis of Alternatives
ASA (ALT)	Assistant Secretary of the Army for Acquisition, Logistics and Technology
ASARC	Army Systems Acquisition Review Committee
CBTDEV	Combat Developer
CDD	Capabilities Development Document
CIO	Chief Information Officer
CPD	Capabilities Production Document
CPIPT	Cost Performance IPT
DAB	Defense Acquisition Board
DoD	Department of Defense
DOTMLPF	Doctrine, Organizations, Training, Materiel, Leadership; Personnel and Facilities
EEA	Essential Elements of Analysis
FEI	Force Effectiveness Indicator
HQDA	Headquarters Department of the Army
ICD	Initial Capabilities Document
ICT	Integrated Concept Team
IPT	Integrated Product Team
JOB	Joint Oversight Board
KPP	Key Performance Parameters
MATDEV	Materiel Developer
MDA	Milestone Decision Authority
MDR	Milestone Decision Review
MNS	Mission Needs Statement
MOE	Measure of Effectiveness
MOM	Measure of Merit
MOP	Measure of Performance
NDI	Non-Developmental Items
ODCSOPS	Office of the Deputy Chief of Staff Operations
OIPT	Overarching Integrated Product Team
ORD	Operational Requirements Document
PEO	Program Executive Officer
PM	Program / Project / Product Manager
RDEC	Research, Development and Engineering Center
RDTE	Research, Development, Test and Evaluation
SAG	Study Advisory Group
TRAC	TRADOC Analysis Center

TRADOC	Training and Doctrine Command
USD (AT&L)	Under Secretary of Defense for Acquisition, Technology and Logistics
WIPT	Working-Level IPT

Definitions

Acquisition Category (ACAT)	Categories established to facilitate decentralized decision-making and execution, and compliance with statutorily imposed requirements. The categories determine the level of review, decision authority, and applicable procedures. DOD 5000.2-R, part 1, provides the specific definition for each acquisition category (ACAT I through III). CJCSI 3170.01B
Acquisition Category I (ACAT I)	A major defense acquisition program (MDAP) subject to Defense Acquisition Board oversight and estimated by the USD (AT&L) to require an eventual total expenditure of more than $365 million in RDT&E funds, or $2.190 billion in procurement funds measured in FY2000 constant dollars. CJCSI 3170.01B
Acquisition Category IA (ACAT IA)	A major automated information system (MAIS) acquisition program that is estimated to require program costs in any single year in excess of $32 million, total program costs in excess of $126 million, or total life cycle costs in excess of $378 million (FY 2000 constant dollars). DoDI 5000.2
Acquisition Category IAC (ACAT IAC)	ACAT IAC programs, delegated to the Army, are Major Automated Information Systems (MAIS) for which the MDA has been designated as the Army CIO. These programs receive an Army Major Automated Information Systems Review Council (MAISRC) review and require a decision by the CIO at each milestone review. AR 70-1
Acquisition Category IAM (ACAT IAM)	A major automated information system (MAIS) acquisition program for which the MDA is the Chief Information Officer (CIO) of the Department of Defense (DOD), the ASD (C3I). CJCSI 3170.01B
Acquisition Category IC (ACAT IC)	ACAT IC programs, delegated to the Army, are Major Defense Acquisition Programs (MDAP) for which the MDA has been designated as the AAE. These programs receive an Army Systems Acquisition Review Council (ASARC) review and require a decision by the AAE at each milestone review. AR 70-1
Acquisition Category ID (ACAT ID)	A major defense acquisition program (MDAP) for which the MDA is USD (AT&L). The "D" refers to the Defense Acquisition Broad (DAB), which advises the USD (AT&L) at major decision points. CJCSI

	3170.01A
Acquisition Category II (ACAT II)	ACAT II programs are acquisition programs that do not meet the criteria for an ACAT I program, but do meet the criteria for a major system. These programs are managed by a PM who reports to a PEO or a materiel command as designated by the AAE. These programs receive an Army Systems Acquisition Review Council (ASARC) review and require a decision by the AAE at each milestone review. AR 70-1
Acquisition Category IIA (ACAT IIA)	ACAT IIA are Automated Information System programs that do not meet the criteria for ACAT IA, but are designated by the AAE/Army CIO for PM management and Army Major Automated Information Systems Review Council (MAISRC) review. AR 70-1
Acquisition Category III (ACAT III)	ACAT III programs are non-major programs (including non major AIS programs) that are designated by the AAE or CIO, due to special interest and are managed by a PM who reports to a PEO or a materiel command as designated by the AAE or CIO. These programs receive an IPR and require a decision by the PEO or the commander of the materiel developing command at each milestone review point. AR 70-1
Acquisition Category IV (ACAT IV)	The Army will utilize the designation of ACAT IV for those programs not designated as ACAT I, II, III and to differentiate these non-major programs managed by a systems manager within a materiel command rather than by a PM. The programs receive an IPR and require a decision by the materiel command commander (or appointed designee) at each milestone review. AR 70-1
Acquisition Decision Memorandum (ADM)	The USD (AT&L) shall decide upon the appropriate implementing actions to be taken as a result of DAB reviews, to include the establishment of specific exit criteria that must be satisfactorily demonstrated before an effort or program can progress to the next Milestone decision point. The USD (AT&L)'s decisions shall be reflected in an Acquisition Decision Memorandum issued by the USD (AT&L) for implementation by the heads of the DoD Components. DoDD 5134.1
Analysis of Alternatives (AoA)	The evaluation of the operational effectiveness and estimated costs of alternative material systems to meet a mission need. The analysis assesses the advantages and disadvantages of alternatives being considered to satisfy requirements, to include the sensitivity of each alternative to possible changes in key assumptions or variables. The AoA assists decision makers in selecting the most cost-effective material alternative to satisfy a

	mission need. CJCSI 3170.01A
Baseline	A baseline is a record, or “snapshot” taken at a specific time in the project. A baseline is useful for comparing your current schedule with later versions of the schedule to see what changes have occurred.
Combat developer (CBTDEV)	Command or agency that formulates and documents operational concepts, doctrine, organizations, and or materiel requirements (ICD, CDD and CPD) for assigned mission areas and functions. Serves as the user representative during acquisitions for their approved materiel requirements as well as doctrine and organization developments. AR 71-9 TRADOC is the Army’s largest combat developer.
Critical Design Review (CDR)	During System Development and Demonstration, the CDR provides an opportunity for mid-phase assessment of design maturity as evidenced by such measures as, the number of completed subsystem and system design reviews; the percentage of drawings completed; adequate development testing; a completed failure modes and effects analysis; identifying key system characteristics and critical manufacturing processes; and the availability of reliability targets and a growth plan; etc. Successfully completing Critical Design Review ends System Integration and continues System Development and Demonstration into the System Demonstration work effort.
Defense Acquisition Board (DAB)	The DAB shall advise the Under Secretary of Defense (Acquisition, Technology, and Logistics) on critical acquisition decisions. The Under Secretary of Defense (Acquisition, Technology, and Logistics) shall chair the DAB, and the Vice Chairman of the Joint Chiefs of Staff shall serve as vice-chair. DAB membership shall comprise the following executives: Under Secretary of Defense (Comptroller); Under Secretary of Defense (Policy); Under Secretary of Defense (Personnel & Readiness); Assistant Secretary of Defense (Command, Control, Communications, and Intelligence)/Department of Defense Chief Information Officer; Director, Operational Test and Evaluation; and the Secretaries of the Army, Navy, and the Air Force. The reviews shall focus on key principles to include interoperability, time-phased requirements related to an evolutionary approach, and demonstrated technical maturity. DoD 5000.2-R

Doctrine, organization, training, materiel, leadership, personnel, and facilities (DOTMLPF)	Requirements determination occurs in the order of doctrine, organization, training, materiel, leadership, personnel, and facilities (D-O-T-M-L-P-F), based on expense and timeliness to field a capability. TRADOC PAM 71-9 identifies the procedures needed to develop requirements documents across the DTLOMS domains and leads to specific documentation that outlines the procedures for warfighting requirements determination in those domains
Force Attribute	A characteristic of a system that will influence the accomplishment of the mission of the military force for which it was designed.
Functional Proponent	The Army Staff agency responsible for the subject area in which automation is used or is to be used, including automation in support of the function performed.
Initial Capabilities Document (ICD)	A formatted non-system-specific statement containing operational capability needs and written in broad operational terms. It describes required operational capabilities and constraints to be studied during the Concept Exploration and Definition Phase [now named Concept and Technology Development Phase]. CJCSI 3170.01B
Integrated Concept Team (ICT)	An integrated team made up of people from multiple disciplines formed for the purposes of developing operational concepts, developing materiel requirements documents, developing other DTLOMS requirements documents, when desired, and resolving other requirements determination issues. AR 70-1 The ICT produces the ICD, architecture documents, CDD, and CPD. ICTs are formed to accomplish the following: (1) Develop capstone and subordinate TRADOC Pam 525-series concepts and associated FOCs. (2) Develop new and validate current FOCs published in TRADOC Pam 525-66. (3) Determine and document warfighting mission needs analysis across all DTLOMS domains. TRADOC PAM 71-9
Integrated Product Team (IPT)	A working level team of representatives from all appropriate functional disciplines working together to build successful and balanced programs, identify and resolve issues, provide recommendations to facilitate sound and timely decisions. AR 70-1
Key Performance Parameters (KPPs)	Those capabilities or characteristics considered most essential for successful mission accomplishment.

	Failure to meet a KPP threshold can be cause for the concept or system selection to be reevaluated or the program to be reassessed or terminated. Failure to meet a KPP threshold can be cause for the family-of-systems or system-of-systems concept to be reassessed or the contributions of the individual systems to be reassessed. KPPs are validated by the JROC. KPPs are included in the APB. CJCSI 3170.01A
Materiel Developer (MATDEV)	The RDA command, agency, or office assigned responsibility for the system under development or being acquired. The term may be used generically to refer to the RDA community in the materiel acquisition process (counterpart to the generic use of CBTDEV). AR 70-1
Measures of Effectiveness (MOE)	MOEs are measures of a unit's or system's ability to perform its operational missions (e.g., probability of kill, tonnage delivered, probability of successful message delivery, loss exchange ratio)
Measures of Performance (MOP)	MOPs are system characteristics (e.g., speed, reliability, bit error rate). MOPs can be either operational (including soldier and environment) or technical (controlling or excluding soldier and/or environment).
Milestone Decision Authority (MDA)	The individual designated in accordance with criteria established by the Under Secretary of Defense for Acquisition, Technology, and Logistics, or by the Assistant Secretary of Defense for Command, Control, Communications and Intelligence for AIS programs, to approve entry of an acquisition program into the next phase of the acquisition process. DoDD 5000.1
Milestone Decision Review (MDR)	MDRs are formal decision briefings to the MDA. These reviews provide the gateway for program progress through the acquisition phases.
Mission Need Statement (MNS)	A formatted non-system-specific statement containing operational capability needs and written in broad operational terms. It describes required operational capabilities and constraints to be studied during the Concept Exploration and Definition Phase [now named Concept and Technology Development Phase]. CJCSI 3170.01B
Non-Developmental Item (NDI)	(1) Any previously developed item of supply used exclusively for governmental purposes by a Federal Agency, a State or local government, or a foreign government with which the United States has a mutual defense cooperation agreement; (2) any item described in (1) that requires only minor modification or modifications of a type customarily available in the

	commercial marketplace in order to meet the requirements of the procuring department or agency; or (3) any item of supply being produced that does not meet the requirements described in (1) or (2) solely because the item is not yet in use.
Operational and Organizational Plan (O&O Plan)	A document developed under the parent Capstone Concept or subordinate concept. The O&O is a plan of how the proponent wants to proceed. It identifies the more detailed operational environment, operational missions, and capabilities planned to be carried out in a full military role. The O&O also puts forth an organizational structure that is to be placed on the battlefield to carry out that operational mission. The O&O says what is going to happen and who is going to do it.
Operational Requirements Document (ORD)	A formatted statement containing performance and related operational parameters for the proposed concept or system. Prepared by the user or user's representative at each milestone beginning with Milestone B. CJCSI 3170.01A
Overarching Integrated Product Team (OIPT)	The OIPT is a team appointed by the MDA, commensurate with the ACAT level, to provide assistance, oversight and independent review for the MDA, as the program proceeds through its acquisition cycle. AR 70-1
Study Advisory Group (SAG)	An advisory group convened by a study sponsor and composed of representatives of various HQDA organizations, Army staff agencies, and major Army commands having a clear functional interest in the study topic or use of study results.